

1. A key actuation system for a keyboard instrument of the type having a plurality of keys, each key having an upper surface and a lower surface and being pivotally supported above a key bed, each key further having a front end that is depressed by a player to play a note, the key bed extending under and spaced from the lower surface of the key, the actuation system comprising:

an underlever disposed in the space between the lower surface of the key and the key bed and between the front end of the key and the pivotal support, the underlever having a first end that is supported in a stationary position relative to the key bed, a second end that is movable towards and away from the key bed, and a midportion therebetween, the second end of the underlever being in mechanical communication with the key such that movement of the second end of the underlever towards the key bed causes the key to move as if depressed by a player;

an actuator in mechanical communication with the underlever and operable to move the second end of the underlever towards the key bed.

2. The key actuation system according to claim 1, wherein the actuator comprises a pull solenoid having a coil portion and a piston, the solenoid operative when the coil portion is energized to draw the piston into the coil portion, the solenoid mounted such that the coil portion is disposed below the midportion of the underlever, the piston being in mechanical communication with the midportion of the underlever such that when the coil portion of the solenoid is energized, the piston pulls the midportion of the underlever downwardly causing the second end of the underlever to move towards the key bed. .

3. The key actuation system according to claim 1, wherein the actuator comprises a push solenoid having a coil portion and a piston, the solenoid operative when the coil portion is energized to push the piston out of the coil portion, the solenoid mounted such that the coil portion is disposed above the midportion of the underlever, the

piston being in mechanical communication with the midportion of the underlever such
6 that when the coil portion of the solenoid is energized, the piston pushes the midportion
of the underlever downwardly causing the second end of the underlever to move towards
8 the key bed. .

4. The key actuation system according to claim 1, wherein the underlever is a
2 flexible underlever that flexes when the actuator moves the underlever. .

5. An actuation system for a keyboard instrument of the type having a
2 plurality of pivotally supported keys having front ends that are depressed by a player to
play a note, the keyboard instrument further having a counterweight system comprising a
4 counterweight that is in mechanical communication with one of the keys such that
depression of the front end of the key causes the counterweight to move in a first
6 direction, the actuation system comprising:

an actuator operable to move the counterweight in the first direction. .

6. The actuator system according to claim 5, wherein the counterweight is
2 pivotally supported and pivots when the key is depressed, the first direction being a
rotational direction and the actuator being operable to pivot the counterweight in the first
4 rotational direction. .

7. The actuator system according to claim 5, wherein the actuator is a push
2 solenoid having a coil portion and a piston, the actuator operable when the coil portion is
energized to push the piston at least partially out of the coil portion, the solenoid being
4 mounted such that the piston is in mechanical communication with part of the
counterweight and is operable to push on the part of the counterweight when the coil
6 portion is energized to cause the counterweight to move in the first direction. .

8. The actuator system according to claim 5, wherein the actuator is a pull
2 solenoid having a coil portion and a piston, the actuator operable when the coil portion is
energized to draw the piston into the coil portion, the solenoid being mounted such that
4 the piston is in mechanical communication with part of the counterweight and is operable
to pull on the part of the counterweight when the coil portion is energized to cause the
6 counterweight to move in the first direction. .

9. The actuator system according to claim 5, wherein a portion of the
2 counterweight comprises a ferromagnetic material and the actuator is operable to
electromechanically move the ferromagnetic material to cause the counterweight to move
4 in the first direction. .

10. A player keyboard instrument for producing notes and actuating the keys
2 to simulate being played by an operator, the keyboard instrument comprising:

a key bed;

4 a plurality of keys, each key having an upper surface and a lower surface and
being pivotally supported above the key bed, each key further having a front end that is
6 depressed by a player to play a note, the key bed extending under and spaced from the
lower surface of the key, each key having a post extending downwardly from the lower
8 surface of the key towards the key bed, the post including a portion of ferromagnetic
material;

10 a counterweight system comprising a plurality of counterweights, one of the
counterweights being in mechanical communication with each of the keys such that
12 depression of the front end of each key causes the corresponding counterweight to move
in a first direction;

14 a plurality of actuator coils disposed in the space between the lower surface of the
keys and the key bed, one of the actuator coils being disposed about each of the posts,

- 16 each actuator coil operable to electromechanically move the ferromagnetic portion of the
corresponding post downwardly so as to move the corresponding key. .

- 2 11. A key actuation system for a keyboard instrument of the type having a
plurality of keys, each key being pivotally supported and having a front end that is
depressed by a player to play a note, the actuation system comprising:
4 a plurality of actuators operable to move at least some of the plurality of keys, the
plurality of actuators together comprising:
6 a block of ferromagnetic material with a plurality of bores defined therein,
a winding disposed in each of the bores, each of the windings having a
8 hole defined therein, and
a piston at least partially disposed in each of the holes, each piston being
10 in mechanical communication with one of the keys such that movement of the piston
causes movement of the key;
12 wherein energizing one of the windings causes the corresponding piston to
move relative to the winding, thereby moving one of the keys. .

- 2 12. The key actuation system according to claim 11, wherein each of the keys
further has a rear end that moves upwardly when the front end is depressed, the actuation
system further comprising a plurality of underlevers each having a movable end and a
4 mounted end, the movable end being positioned under the rear end of one of the keys
such that upward movement of the movable end causes the movable end to lift the rear
6 end of the key upwardly, the underlevers providing the mechanical communication
between the pistons and the keys. .

- 2 13. The key actuation system according to claim 12, wherein the block is
positioned rearwardly of the rear ends of the keys and the underlevers are disposed above
the block, the plurality of actuators being push solenoids such that energizing the

- 4 windings causes the pistons to move upwardly out of the holes in the windings and push
on the underlevers. .

2 14. The key actuation system according to claim 12, wherein the block is
positioned rearwardly of the rear ends of the keys and the underlevers are disposed below
the block, the plurality of actuators being pull solenoids such that energizing the windings
4 causes the pistons to be drawn upwardly into the holes in the windings and to pull on the
underlevers. .

2 15. The key actuation system according to claim 11, further comprising a
plurality of underlevers each having a movable end and a mounted end, the movable end
being positioned under the one of the keys between the front end of the key and the
4 pivotal support, the movable end being in mechanical communication with the key such
that downward movement of the movable end causes the front end of the key to be
6 moved downwardly, the underlevers providing the mechanical communication between
the pistons and the keys. .

2 16. The key actuation system according to claim 15, wherein the block is
positioned below the underlevers, the plurality of actuators being pull solenoids such that
energizing the windings causes the pistons to be drawn downwardly into the holes in the
4 windings and to pull down on the underlevers. .

2 17. The key actuation system according to claim 15, wherein the block is
positioned below the keys and above the underlevers, the plurality of actuators being
push solenoids such that energizing the windings causes the pistons to move downwardly
4 out of the holes in the windings and to push down on the underlevers. .

18. A key actuation system for a keyboard instrument of the type having a key
2 fulcrum pivotally supporting a plurality of keys, each key having a front end disposed
forward of the fulcrum which is depressed by a player, and a rear end disposed rearward
4 of the fulcrum that pivots upwardly when the front end is depressed, said system
comprising:

6 a pivotal support;

a rocking lever arm supported by the support and having a lifting end on one side
8 of the support in mechanical communication with the rear end of one of the keys and a
piston end on the other side of the support, the piston end including a portion of
10 ferromagnetic material; and

an actuator coil having a opening therein, the coil disposed such that the piston
12 end of the lever arm is at least partially disposed in the opening, the actuator operable to
electromechanically move the piston end of the lever arm. .

19. The actuation system according to claim 18, wherein the piston end of the
2 rocking lever arm is generally blade shaped and the coil is generally rectangular with a
generally rectangular opening therein. .

20. The actuation system according to claim 18, wherein the pivotal support is
2 disposed rearward of the rear end of the key and the piston end of the lever arm is
positioned rearward of the pivotal support. .

21. A key actuation system for a keyboard instrument of the type having a
2 plurality of pivotally supported keys each having a front end which is to be depressed by
a player to pivot the key, said system comprising:

4 a primary underlever having a mounted end and a free end that is movable in at
least a first direction;

6 an actuator operable to move the primary underlever such that the free end of the
primary underlever moves in the first direction; and
8 a secondary underlever having a mounted end and a free end that is movable in at
least a second direction, the free end being in mechanical communication with one of the
10 keys such that when the free end of the secondary underlever moves in the second
direction, the key pivots as if depressed by a player, the secondary underlever further
12 having a midportion defined between the mounted and free ends;
the free end of the primary underlever being in mechanical communication with
14 the midportion of the secondary underlever such that when the free end of the primary
underlever moves in the first direction, the free end of the secondary underlever is moved
16 in the second direction. .

22. A player keyboard instrument for producing notes and actuating the keys
2 to simulate being played by an operator, the keyboard instrument comprising:
a plurality of pivotally supported keys, each key having an upper surface and a
4 lower surface, each key further having a front end that is depressed by a player to play a
note, each key having a post extending downwardly from the lower surface of the key,
6 the post including a portion of ferromagnetic material;
a sensor operable to sense movement of the posts of each of the keys;
8 a sound reproduction system in communication with the sensor and operable to
produce sound in response to movement of the posts; and
10 a plurality of actuator coils, one of the actuator coils being disposed about each of
the posts, each actuator coil operable to electromechanically move the corresponding post
12 downwardly so as to move the corresponding key. .

23. The keyboard instrument according to claim 22, wherein the sensor
2 comprises a plurality of individual sensors. .

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24. The keyboard instrument according to claim 22, wherein each of the posts
2 includes a finger extending from a lower end thereof, the sensor being operable to sense
movement of fingers.